USER'S MANUAL

Water Quality Capture Optimization and Statistics Model (WQ-COSM)

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Introduction

Water Quality Capture Optimization Statistical Model (WQ-COSM) is a Windows-based computer program that uses recorded rainfall data from the National Climatological Data Center (NCDC) and information about the catchment's hydrologic parameters to help the user determine the water quality capture volume (WQCV) and the maximized WQCV for any type of stormwater treatment facility (i.e., structural Best Management Practice (BMP)) that captures runoff in temporary storage vessel for mitigating of hydrologic changes caused by urbanization and treatment of water quality through sedimentation, biological uptake of pollutants and/or filtration/infiltration.

This program replaces a DOS based program called PondRisk (ref.: Guo, James C.Y. (1986). *PONDRISK Computer Model for Determination of Maximized Detention Volume*, Dept. of Civil Engineering, U. of Colorado Denver, Denver, Colorado). WQ-COSM provides a modern user interface and adds additional functionality that was not available in PondRisk. WQ-COSM computes runoff using continuous runoff simulation using either Rational Method or Horton's infiltration method and calculates the WQCV based on the runoff simulation.

WQCV is an integral part of any BMP that remove significant portions of pollutants from the majority of runoff events and to help mitigate the hydrologic changes caused by urbanization. These BMPs differ from flow-through BMPs that do not have a WQCV and do not mitigate the effects of increased stormwater runoff peaks and volumes that result from urbanization. Flow-through BMPs are primarily used to remove gross pollutants consisting of floating trash and coarse sediment, but for the most part, do not remove fine sediment and associated pollutants, bacteria, and dissolved constituents in significant amounts. A WQCV is a part of the following types of BMPs:

- Total storage for an Extended Detention Basin (i.e., dry) basin (EDB)
- As surcharge storage above the permanent pool of a Retention Pond (i.e., wet) pond (RP)
- As surcharge storage above the permanent pool of Wetland Basin (WB)
- Above or upstream of a Media Filters (MF)
- Above of upstream of a Rain Gardens (RG), sometimes called bio-retention cell.

The size (i.e., volume) of the WQCV vessel, or basin, dependent on the runoff that results over time at the catchment and the time it takes to empty a brim-full WQCV vessel (i.e., the rate of discharge from the vessel) when there is no additional runoff entering it.

WQ-COSM is implemented as two programs, a user interface and the math engine. The user interface collects information from the user, generates properly formatted input files for the math engine and displays the results after the math engine has successfully processed the information in the input file.

This manual provides information for installing and running WQ-COSM. For information on the underlying math model, the user is referred to other sources such as the following two:

Guo, James C.Y. and Urbonas, Ben. (2002). *Runoff Capture and Delivery Curves for Storm Water Quality Control Designs*, ASCE J. of Water Resources Planning and Management, Vol 128, Vo. 3, May/June.

Urbonas, B., Guo, Jim C.Y., Tucker, L.S. (1990). *Maximization of Stormwater Quality Volume*, Urban Stormwater Quality Enhancement, Proceedings of an Engineering Foundation Conference held in October 1989, Davos, Switzerland, published by ASCE, Reston, MD.

Description of the WQ-COSM Computer Model to Generate a Capture Volume for Stormwater BMPS, a special report posted on www.urbanwatersheds.org and www.udfcd.org websites under technical papers.

Installing WQ-COSM

WQ-COSM is distributed as a Microsoft Installer package (*.msi). To install, simply double-click on the *WQ-COSM.msi* installer. During the installation process you will be prompted to select an installation type. The 'Typical' install is appropriate for most users. If you select the 'Custom' option, you will with have the option of selecting individual components to install, but unless you have and/or are prepared to install your own support software for the preparation of input files for this model, other options than 'Typical' would be of no benefit and should not be used.

Certain components used by WQ-COSM, particularly Nokia's Qt Framework, are released under the GNU LGPL. Under the terms of this license you are permitted to omit installation of these components in favor of your own version.

WQ-COSM can be uninstalled using the 'Add/Remove Programs' dialog in Windows or by re-running the installer and selecting the 'Uninstall' option.

Using WQ-COSM

To use WQ-COSM, browse on your computer to '**Start->All Programs->UWRI Programs**' and click on 'WQ-COSM.' This will launch the user interface and open up a new WQ-COSM project. Figure 1 is the user interface that will appear.

Parameters are entered or edited using the '**Input Parameters**' section of the interface located on the right hand side of the screen. When entering or editing parameters, once the parameter is selected by the use, a brief description of the selected parameter is provide in the '**Description**' area at the bottom right hand side of the screen.

The values that can be entered or edited under '**Input Parameters**' of the WQ-COSM user interface are as follows:

- **Input File:** For a new run, enter the name (without a file extension) of the file that holds the WQ-COSM input parameters, including its directory location. Software assigns a standard extension *.wqin. The directory location where you want to place this file may be found using the '…' button. To locate an existing input file, use the '**…**' button to navigate yourself to where the file is located.

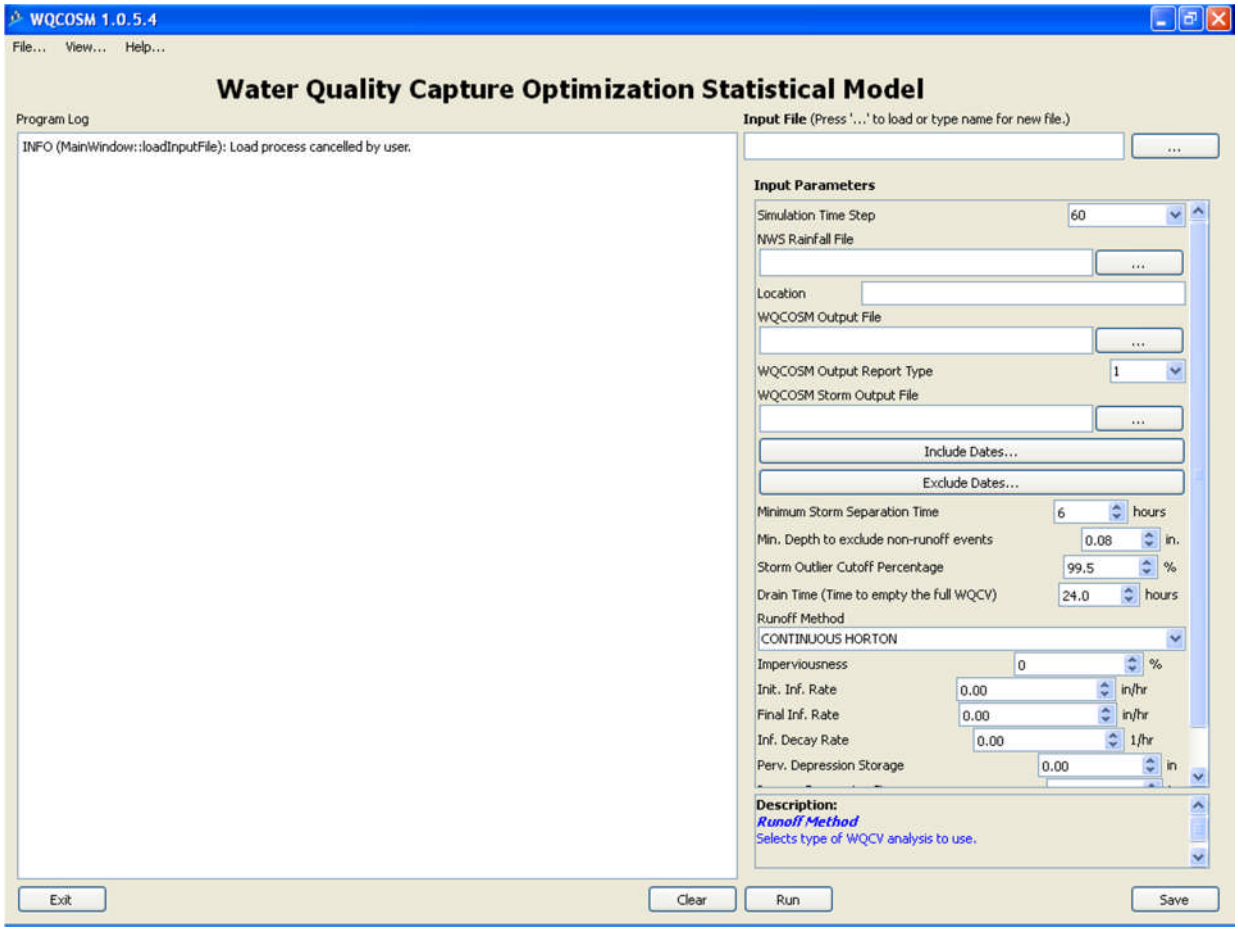

Figure 1. WQ-COSM user interface for the entry of project parameters.

- **Simulation Time Step**: The time step of the rainfall file in minutes (options are 15 minutes and 60 minutes (i.e., 1-hour), defaults to 60 minutes).
- **NWS Rainfall File:** Program uses the comma separated values (*.csv) formatted precipitation data obtained from the National Climatological Data Center (NCDC) operated by NOAA. The 15-minute and the 1-hour data formats are very similar. The only difference is that an hourly file has 25 time-precipitation value pairs per row while the 15 minute file only has one. Either file must have at least three lines. The first line contains column headers. The second line is ignored to allow compatibility with files downloaded from the NCDC website. All remaining lines should contain values associated with the headers from the first line. The column headers, in order, are:
    - ***COOPID***- The Station ID number. This should be the same for all lines.
    - ***CD***-The Cooperative Network Division Number. WQ-COSM does not use it.
    - ***ELEM***- The type of data stored in this record. WQ-COSM does not use it.
    - ***UN***- The minimum reporting increment of the precipitation data. May be either HI when data is reported in hundredths of an inch increments or HT when data is reported tenths of an inch increments.

- ***YEAR***- Four digit year of the data on the current line.
- ***MO***- Two digit month of the year.
- ***DA***- Two digit day of the month.
- ***TIME***- Depending on the type of NCDC data used (i.e., 15-minute or 1-hour) the format will differ. For the one-hour data there are 25 entries of rainfall depth per line (one for each hour plus 1 for the daily total). For the 15-minute data, there is only one rainfall depth entry per line, with the 25th hour line being the daily total value. WQ-COSM does not use the daily total values.
- One value of precipitation depth immediately to the right of each *TIME* column. The headers vary between the 15-minute and 1-hour data files:

  - **For 15-minute data** the columns are ***TIME*** and ***VALUE***, the second being the depth value.

    --Or--

  - **For 1-hour data** the columns that follow are pairs of ***TIME*** and ***HOUR{N}*** and Value- Where ***HOUR{N}*** is a header for the precipitation depths for times {1} through {25} (i.e., hours 1:00 through 25:00 of the day where hour 25 column contains the daily total that WQ-COSM does not use).

- ***F***- There should be two of these to the right of each VALUE or HOUR{N} column. This header indicates that the column holds flags associated with the data. Currently WQ-COSM ignores (i.e., does not use) any of the flagged data.

  It is recommended the user screen the raw data from the NCDC by first opening it in Excel and examining the flags. This examination may cause the user to exclude certain data ranges from analysis.

- **Location:** The user input location describing the location of the rainfall gage used or the location of the project.
- **WQ-COSM Output File:** Enter the output file name, including its directory.
  - The software will generate an HTML format file used to inspect the report generated by the WQ-COSM Math engine. If the display of the results does not occur, add the extension html at the end of the file name (i.e., *.html)
  - This file will be overwritten each time the model runs, unless the user specifies a new file name for the subsequent run.
  - The information contained in the report varies depending on the value of the 'WQ-COSM Output Report Type' specified by the user.
- **WQ-COSM Output Report Type:** User may specify the type of WQ-COSM report to generate. The different report types are:
  - ***Type 1:*** WQCV summary report. Provides a table of all Water Qaulity Capture Volumes calculated by both *Volume Capture Ratio* and *Event Capture Ratio* methods, and displays the maximized capture volumes for each method. User may copy and

paste the tables generated for subsequent analysis or generation of figure using Excel or other software.

  - ***Type 2:*** Statistical summary report. Provides a statistical summary of the storm population along with the maximized water quality capture volume for both *Volume Capture Ratio* and *Event Capture Ratio* methods.
  - ***Type 3:*** Storm summary report. Provided a table of all storms processed by the WQ-COSM program that include total precipitation, runoff, storm duration, time the storm starts and dry period separating the start of the storm and the end of the storm that occurred. Water quality capture information is not reported.

- **Storm Output File:** If the user elects this option, a comma separated file of the same name as the input file is generated that contains all the data listed in *Type 3* output above. This file will be overwritten by subsequent runs unless a different input file name is used. User may import this file into Excel or other software for further analysis.
- **Exclude dates:** Launches a dialog that allows the user to select dates to exclude from analysis. Typically this would be used to exclude data from the winter season. If no dates are specified, WQ-COSM will consider the entire input file.
- **Minimum Storm Separation Time:** Minimum time between consecutive rainfall events that marks the start of a new storm (hours). Typically between 3 - 24 hours (default = 6-hours).
- **Min. Depth to exclude non-runoff events:** Minimum storm depth to be analyzed (inches). Used to exclude non-runoff producing storms. State-of-practice for urban runoff suggests between 0.06 and 0.12 in. (default = 0.08 inches).
- **Storm Outlier Cutoff Percentage:** The upper percentile of the storms to use in WQCV analysis to exclude large outlier storms (default = 99.5%). Storms above this percentile value are not used in finding the Maximized WQCV.
- **Runoff Method:** The type of method to use in calculating the runoff using the continuous rainfall data. Two options are provided, 'Continuous Rational' and Continuos Horton's.
  - **Rational 'C':** User need to enter the Runoff Coefficient when the 'Continuous Rational' method is selected. Runoff coefficient is between 0 and 1.
  - **Horton's Parameters.** Enter the following parameters when "Continuous Horton's" is selected:
    - **Initial Infiltration Rate:** Available when the runoff method is Continuous-Horton. The initial infiltration rate in inches per hour (no default recommended).
    - **Final Infiltration Rate:** Available when the runoff method is Continuous-Horton. The final infiltration rate in inches per hour (no default recommended).
    - **Infiltration Decay Rate:** Available when the runoff method is Continuous-Horton. The infiltration decay rate in 1.0/hr units (no default recommended).
    - **Imperviousness:** Available when the runoff method is Continuous-Horton. The imperviousness of the basin in percent (no default recommended).

- **Pervious Depress Storage:** Available when the runoff method is Continuous-Horton. The maximum pervious depression storage for the basin. This is typically less than 0.5 inches (default = 0.40).
- **Impervious Depression Storage:** Available when the runoff method is Continuous-Horton. The maximum impervious depression storage for the basin. This is typically less than 0.15 inches (default = 0.10).
- **Drying Time:** Available when the runoff method is Continuous-Horton. The time required for the basin to recover its infiltration and depression storage capacity that may vary from 1 to 14 days (default = 3 days).

- **Drain Time:** Emptying time for brim-full WQCV (in hours). Typically range between 12 and 48 hours, dependent on the type of BMP being analyzed (default = 24 hours).

If you have a WQ-COSM project that was saved in the past. It can be opened entering the directory stream and file name or searching for it using '**…**' button next to the input file field. WQ-COSM projects are stored as ***.qvin** files, which is essentially a text file with sections delimited by [SectionName] and parameters defined one per line using 'param=value' syntax. After loading a file, it can be edited just like a new system, but be sure to save the file either using the exiting name or a new name to preserve your edits for future use.

To run the current WQ-COSM project, press the run button. Assuming all input parameters are within the expected range, the WQ-COSM math engine will be called. Any messages from the WQ-COSM math engine will be displayed on the left hand side of the screen. If the math engine completes successfully, a window will be launched where you can view the results file. You will be prompted to save your input before closing the run.

Advanced Usage

Users wishing to run a large number of input files may choose to run the WQ-COSM math engine directly using a batch file or other script. The math engine can be called as shown below:

```
WQ-COSMMath.exe -i=inputfile.ini -o=outputFile.html -r=rainfallFile.csv
```

Additional command line options can be seed by calling `WQ-COSMMath.exe --help`.

Users may also choose to create or edit input files using tools other than the Pond Risk User Interface. The required syntax for input files is provided below:

```
[WQ-COSM]
COOPID= Either 0 or a specific station id to extract from the rainfall file.
cutoffPercent= A value between 1 and 100. Indicates the maximum percentile
      storm to consider in calculations.
stormSepTime= A value in minutes
minStormDepth= A depth in inches
simulationType= SINGLEPOINT or CONTINUOUS
drainTime= A WQCV drain time in hours
```

includeDates= Date ranges in the form ‘mm/dd/yyyy HH:MM:00 - mm/dd/yyyy HH:MM:00’ Multiple ranges are separated by semicolons.
excludeDates= Date ranges in the form ‘mm/dd/yyyy HH:MM:00 - mm/dd/yyyy HH:MM:00’ Multiple ranges are separated by semicolons.
reportType= The type of output report to generate.

Plus one of the following sections:

[HortonBasin]
initInfRate= Initial infiltration rate in in/hr
finalInfRate= Final infiltration rate in in/hr
infDecayRate Infiltration decay rate in 1/hr
imperviousness= Basin imperviousness in percent
pervDepStg= Pervious depression storage capacity in inches
impervDepStg= Impervious depression storage capacity in inches
dryingTime= The drying time of the basin in days

[RationalBasin]
rationalCoeff= The runoff coefficient of the basin. Between 0 and 1

APPENDIX – A

Ranges in Rainfall Losses for Rational and Horton's Methods

Rational Runoff Coefficient 'C'. This coefficient varies with soil type and degree of effective imperviousness of the catchment between 0.0 and 1.0. Based on EPS's Nationwide Urban Runoff Program Data from over 60 different sites in United States and the follow-up analysis performed by the Urban Drainage and Flood Control District (UDFCD) in the Denver Region, the following tables offer suggested values when selecting values of C for use with WQ-COSM to find the WQCV:

Percentage Imperviousness	Runoff Coefficient by NRCS Hydrologic Soil Groups		
	C & D	B	A
0%	0.04	0.02	0.00
10%	0.11	0.06	0.00
20%	0.17	0.12	0.06
30%	0.22	0.18	0.13
40%	0.28	0.23	0.19
50%	0.34	0.29	0.25
60%	0.41	0.37	0.33
70%	0.49	0.45	0.42
80%	0.60	0.57	0.54
90%	0.73	0.71	0.69
100%	0.89	0.89	0.89

Horton's Method Parameters. The following infiltration parameters are suggested and are based for pervious surfaces originally suggested by Akan (1993) and others and for impervious surfaces suggested by a number of investigators and the studies done by UDFCD:

Horton's Initial Infiltration by Soil Type

Soil Type	(in/hr)	(mm/hr)
Dry sandy soils with little or no vegetation	5.0	127
Dry loam soils with little or no vegetation	3.0	76.2
Dry clay soils with little or no vegetation	1.0	25.4
Dry sandy soils with dense vegetation	10.0	254
Dry loam soils with dense vegetation	6.0	152
Dry clay soils with dense vegetation	2.0	51
Moist sandy soils with little or no vegetation	1.7	43
Moist loam soils with little or no vegetation	1.0	25
Moist clay soils with little or no vegetation	0.3	7.6
Moist sandy soils with dense vegetation	3.3	84
Moist loam soils with dense vegetation	2.0	5.1
Moist clay soils with dense or no vegetation	0.7	18

Horton's Infiltration Decay Rate can vary considerably. Most reported values in use by modelers range from 2 to 6/hr (0.00056 to 0.00167/sec). Because there is little sensitivity in final results after the value of 3/hr is used, it is recommended for use with WQ-COSM when evaluating B, C and D soil types and a value of 2/hr when evaluating type A soils.

Horton's Final Infiltration Rate by Soil Type

	Final Infiltration Rate	
Soil Type	(in/hr)	(mm/hr)
Clay loam, silty clay loam, sandy clay, silty clay, clay	0.00 - 0.05	0.00 - 1.3
Sandy clay loam	0.05 - 0.15	1.3 - 3.8
Silt loam, loam	0.15 - 0.30	3.8 – 7.6
Sand, loamy sand, sandy loam	0.30 - 0.45	7.6 – 11.4

The final or minimum infiltration rate is often the saturated hydraulic conductivity rate of the soil

Impervious Surface Depression Storage can also vary considerably depending on the type of the surface and its condition. Water stored in depressions on impervious areas is lost through evaporation. Kidd (1978) developed the following relationship for depression storage as a function of catchment slope which has a regression coefficient of 0.85:

$$D = K\ (0.0303 \cdot S^{-0.49})$$

In which, D = depression storage, inches and S = catchment slope, percent.

Typical values in use by modelers range form 0.04 to 0.12. A value of 0.08 inches is recommended for use with WQ-COSM

Pervious Depression Storage in inches or millimeters has to be filled up before runoff begins and is subject to both infiltration and evaporation. For grassed urban surfaces this ranges from 0.25 to 0.5 inches (6 to 13 mm) and a value 0 0.3 inches (7.6 mm) is recommended for use with WQ-COSM.

Drying Time used by modelers typically varies from 1 to 14 day depending on local climate during the rainfall seasons. A value of 3 days is suggested for use with WQ-COSM in most of United States except in regions of prolonged precipitation and high humidity where longer periods may be more appropriate and in regions with very dry climates where shorter periods should be used.